

pable of more critical analyses of management alternatives.

## **Challenges to Managers**

More sophisticated models do not mean that the range manager or the wildlife or fisheries biologist of the future will simply be a mechanic punching keys at a computer terminal. On the contrary, the life of the professional natural-resource manager will be more exciting and challenging because of the vastly superior information base to work with and the tools to use that information properly. Data bases, habitat capability models, and simulation models will supplement the resource manager's knowledge, not replace it.

There will still be hard choices to make. Natural resource managers will still face a dilemma: how to arrive at the best decision when many of the socioeconomic variables, so important in the decisionmaking process, remain intangible. They can't have more of everything. Compromise will remain a must. Effective integrated management requires decisions which implement Federal and State laws and balance resource outputs with public needs and desires.

Resource management will not be integrated without soul searching, conflict, and goal setting. Data bases and models will vastly help with sorting information, identifying alternatives, evaluating consequences of those alternatives, forecasting, and so forth. But they are only tools; they alone will not integrate the management process. Professional, trained resource managers are still the operative element. Only through a concerted effort by the trained manager will all resources be integrated and true multiple-use management be realized. Through research today, the resource manager of forests and rangelands of the future will have the tools to breach the maze.

# **Forest Land- Management Decisions**

Nelson S. Loftus, Jr., *principal research silviculturist, Timber Management Research Staff, Forest Service*

**O**ne-third of our Nation's total land area is covered by forests, and nearly two-thirds of this forest is capable of growing continuous crops of trees and other forest products. The full benefits from this renewable resource, however, cannot be realized without proper forest management supported by a dynamic research program. Management programs are often judged to be good or bad based on how they affect development of a forest and whether this forest provides the mix of goods and services required by our society.

Forest land managers have long wished for a view of the future forest that reflects the consequences of their management decisions. Today, the application of computer technology to the quantitative analysis of the forest resource gives the land manager that look into the future. Future advances in mathematical modeling and our understanding of the biological aspects of the forest will increase the precision and reliability of this forecasting.

## **Computer Models**

To a large measure, forest land management has historically been based on our ability to estimate changes in tree growth and volume yield (productivity) in response to specific silvicultural treatments. In the last two decades, research has developed growth and yield prediction methodology using new computer technology

and greater analytical expertise. Much of the advancement in this area occurred because of the need for more accurate predictions of productivity to avoid costly errors and controversy and to increase the precision of forest-management planning. Advancement also has been in response to increasing numbers of knowledgeable users and new areas of application. Traditional yield tables that emphasized merchantable timber (because wood was the primary reason for investment) are being replaced by highly sophisticated computer models that consider wildlife habitats, watershed protection, recreation, pest management, and esthetics, as well as timber values. A discussion of models to simulate the natural and modified development of the forest and their use in making forest land-management decisions follows.

**Information Needed.** What information about a forest is needed to model its growth and yield? The future of a forest depends on regeneration—the establishment of seedlings; tree growth as expressed by diameter, height, and volume measurements; and tree mortality. Development of these models also requires knowledge of forest dynamics and the analytical tools for summarizing, analyzing, and recording the complex biological interactions that characterize the forest ecosystem. The task of simulating the growth and development of the forest becomes even more complex when managers want to see what may happen if they engage in various management activities.

Fortunately, numerous models have been developed to describe the present forest and predict its response to change resulting from human activities and natural events. Using these computerized models, an inventory of the forest, and a “what if” approach to the decisionmaking process, forest

land managers can now generate alternative forest-management solutions to many complex problems. But, the selected course of action is still based on the manager’s expertise; the model and computer program are only tools facilitating the decision process.

**Future Model Uses.** In the future, forest managers will use models to characterize the resource, predict the future growth and development of the forest, and examine the likely consequences of management activities with greater and greater precision. In addition, models will predict the impacts of insects and diseases on forest development. These will allow the manager to evaluate quickly and economically the cost and potential benefits of alternative pest-management methods, including the use of genetically resistant planting stock. The integration of pest-management and forest-growth models will permit the manager to compare both forest-management and pest-control strategies in terms of volume growth over time.

Genetics research will develop procedures to quantify improvements in tree growth and pest resistance in such a way that they can be incorporated into yield-prediction systems. Inclusion of genetic gain information into growth and yield models will permit estimates of increased production based on differences between genetically improved and nonimproved planting stock growing under various cultural treatments. With these genetic gain benefit estimates, forest land managers can assess the potential value of improved planting stock (“super” trees) in their operations and determine how and when to modify management practices to maximize economic returns.

Increasingly, regeneration establishment models will be used to predict expected results of regeneration

prescriptions and project the growth and development of seedlings into the mature forest. Combined with appropriate growth models, managers will be able to test site-preparation treatments, evaluate the need for supplementary planting or seeding, and project not only the number of seedlings surviving but also the species composition of the new forest.

Other models will become available that tie silviculture to wildlife and watershed management concerns, including descriptions of the predicted understory species, animal habitat requirements, and hydrologic relationships. Use of such models will permit land managers to consider (1) how the planned management of the trees will affect the wildlife habitat values of the forest and the hydrologic characteristics of the watershed, and (2) how managing for these resources will affect the development of trees.

Finally, the usefulness of these advanced models as tools for making land-management decisions will be greatly reinforced when they are linked with economic models. Here the manager of the future will supply the current resource values and the related costs of management and the computer will calculate revenues. Economic analyses will include discounted costs and incomes, net present value, the benefit/cost ratio, and internal rates of return for the various management strategies.

### **Decision-Support Systems**

Currently, computer applications in forestry are typically data-processing oriented; that is, data are processed to provide information used to make a decision. For example, a manager calculates the volume of timber on an area as a basis for planning and implementing a harvest schedule. In the future, however, computers will be used more to analyze the processed

information for the purpose of making decisions, that is, decision support. Complete stand analysis and prescription procedures will be developed that not only provide a systematic way of measuring and evaluating critical conditions but also use data to arrive at recommended treatment alternatives. Using forest inventory information, a computer program will do the entire job of analysis, prescription, and report preparation. Such a decision-support system, like other forestry tools, will help the manager to decide among the alternatives for treating the forest on the basis of the best projections of the results of a decision.

In the 21st century, computers will provide increasingly valuable assistance to the forest land manager in analyzing the data necessary to perform inventory, appraisal, economic analysis, management planning, harvest scheduling, pest management, regeneration, and other tasks. These models of the future will make it possible to comprehend and analyze the complex biological and economic relationships found in the forest. As a result, forest land-management decisions will be easier, better, and based on the best available scientific knowledge.